STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A REPORT ON

THE INVESTIGATION OF THE CORROSION OF

THE UNDERGROUND PIPING SYSTEM

LOCATED AT THE VENTURA COUNTY FAIR GROUNDS

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

August 1960

Lab. Project Auth. 72-S-6211

Mr. James F. Koenig, Secretary-Manager
31st District Agricultural Association
P. O. Box 888
Ventura, California

Dear Sir:

Submitted for your consideration is:

A REPORT ON

THE INVESTIGATION OF THE CORROSION OF THE UNDERGROUND PIPING SYSTEM LOCATED AT THE VENTURA COUNTY FAIR GROUNDS

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work supervised by . . . . R. F. Stratfull
Report prepared by . . . . W. L. Flaxa and R. F. Stratfull

Very truly yours,

F. N. Hveem
F. N. Hveem
Materials and Research Engineer

WLF/RFS:mw
cc: CJSchultz (3)

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TABLE OF CONTENTS

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I. INTRODUCTION AND HISTORY

On November 20, 1959, Mr. James F. Koenig, Secretary-Manager of the 31st District Agricultural Association, requested by letter that the Materials and Research Department perform a corrosion survey of the underground water lines at the Ventura County Fair Grounds. The work was performed under Laboratory Project Authorization 72-S-6211 during the week of July 11, 1960.

Historically the Ventura County Fair Grounds have been in the same location since some time between 1875-1900. Underground piping has been installed and abandoned during various periods of construction. As a result, the ages of many existing facilities are not definitely known.

During 1958 and 1959 two leaks occurred in the 6" water line installed in approximately 1952. In addition to the leaks in this 6" water line, numerous leaks have been repaired during the past three years in other sections of the older piping system. Leaks in the water system have occurred during the Fair period and have resulted in inconvenience to the public and disrupted the operations of the facilities.

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II. SUMMARY AND CONCLUSIONS

The leaks in the water system will continue at an ever-increasing rate. It is anticipated that within the near future the maintenance personnel will not be able to repair the leaks in the older piping as they are detected.

The inspection of the piping in various locations indicates that the over-all application of cathodic protection will indirectly cause new water leaks to appear. This is because a rust coating is probably acting as a "plug" for many of the leaks. The application of cathodic protection would loosen the rust "plug", allowing the pipe to leak water.

The soil at the Fair site is corrosive to metal pipe. In addition there are stray electrical currents emanating from some unknown source. These stray electrical currents are causing the metal pipe to corrode. The magnitude of these stray currents or their effect on the "normal" corrosion rate was not investigated. These factors were not investigated as it did not appear to be economically advisable.

In the locations where the piping is less than ten years old, it is suggested that the maintenance force install a magnesium anode when a leak is repaired. The installation of the magnesium anode at the repair should increase the life of the pipe at this particular location and should also reduce the probability of any additional leaks adjacent to the area of repair.

It is not considered that the placement of magnesium anodes at the areas of repair is a permanent method for preventing corrosion. The magnesium anodes would have to be replaced periodically, as they will be consumed as they develop the protective electrical currents. Therefore, if a pipe replacement program is an economical method for continuing to supply water to the various facilities, then the replacement of the relatively new metallic piping installed in approximately 1951 should be considered.

It is suggested that any new piping installed underground at this site be non-metallic where it is mechanically feasible.

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III. RECOMMENDATIONS

1. That, where feasible, all new underground piping be nonmetallic in composition.
2. Metallic pipe, if used, should not be directly in contact with the soil.
3. A magnesium anode should be placed at all areas of repair to metallic pipe except where pitting or the general loss of metal in adjacent areas indicates that less than 1/2 of the original pipe wall thickness is containing the flow.
4. That the Fair Grounds immediately purchase twelve (12) magnesium anodes to install "hot spot" cathodic protection at each location where a pipe is repaired (see 3 above).
5. That an economic analysis be made between (1) the cost of the continuing repairs to the pipe and the intermittent loss of service and (2) the cost of pipe replacement.

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IV. TESTS

A. Pipe to Soil Measurements

The flow of galvanic current from a corroding metallic structure can be detected by measuring the electrical voltage drops in the soil about the structure.

The voltage drop, or the pipe to soil potentials, of the underground structure is measured with a standard copper sulfate half cell and a high impedance voltmeter.

It was not economically feasible to make a complete survey of pipe to soil measurements because the pipe was not electrically connected throughout the system. In order to obtain the pipe to soil potentials of the entire piping system, these electrical discontinuities would have to be located, dug up, and electrically connected to the measuring circuit.

The 6" pipe across the east end of the race track was found to be electrically continuous and the pipe to soil potentials of this single run of pipe were measured.

These potential measurements indicated that the pipe was generally corroding throughout its length. In addition, the corrosion rate of this pipe in one area appeared to be somewhat reduced as a result of a stray electrical current. At some undetermined location, the stray electrical current is causing the accelerated loss of an underground metallic structure.

B. Electrical Resistivity of the Soil

Since the corrosion of the underground piping is electrochemical in nature, either the presence or the absence of certain chemicals will affect the magnitude of the galvanic currents developed. Likewise, the electrical resistivity of the soil, through which the electrical corrosion currents must flow, has a direct bearing on the rate of corrosion -- the lower the electrical resistivity of the soil, the greater the possible flow of current.

In the final analysis a high current flow is directly related to a high rate of corrosion attack.

The electrical resistivity of the soil at the Ventura County Fair Grounds is shown on Exhibit I, Equi-Resistivity Contour Map. As shown by the earth resistivity measurements, the soil varies from 275 to 1600 ohm cm. The average soil resistivity is approximately 650 ohm cm, which indicates a moderately corrosive soil on the average. However, there are general locations where the soil is classified as severely corrosive.

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V. DISCUSSION

A. Soil Corrosivity

One of the most widely used simple criteria for anticipating or comparing the corrosivity of soils is the measurement of their electrical resistivity. The resistivity of a soil is described in ohm cm, which is the electrical resistance, in ohms, of a cubic centimeter of soil. The lower the electrical resistance the greater the current flow and thus the greater the corrosion rate, when other conditions are equal.

The August 1931 issue of Western Gas presented the following classifications of soil corrosivity as related to the specific electrical resistance of such soils:

Resistivity ohm-cm	Corrosivity
0 - 400	Severely corrosive
400 - 1200	Moderately corrosive
1200 - 4000	Mildly corrosive
4000 - 10000	Slightly corrosive

Resistivity ohm-cm	Probable Life of Bare Steel Pipe in Years
0 - 1000	0 - 0
1000 - 2500	9 - 15
2500 - 10000	15 or more

As will be noted, the average electrical resistivity of the soil at the Ventura County Fair Grounds falls in the general classification of a moderately corrosive soil.

The table indicates that a bare steel pipe buried in this moderately corrosive soil will have a service life between 0 - 9 years.

Based upon the preliminary studies of the Materials and Research Department on estimating the life of underground pipe, the time to a perforation of 6" bare steel pipe in the more highly corrosive soil, such as is located at the Ventura County Fair Grounds could be about 15 years, a 3" bare steel pipe could be about 12 years, and a 3/4" bare steel pipe could be about 6 years. The differences in life of the various sizes of pipes is due to the differences in the pipe wall thickness.

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B. Cathodic Protection

Cathodic protection is a method employed to control the corrosion of underground pipe. Essentially, the process consists of applying an electrical current to the surface of the pipe. As the corrosion of the pipe has an electrical current discharge, then the current applied by means of cathodic protection can be figuratively said to "buck out" these damaging corrosion currents.

When cathodic protection is applied to a pipe, a film of hydrogen gas will form on the surface of the pipe. If the pipe that has cathodic protection applied to it to prevent additional corrosion is already badly corroded, its condition will not be changed. In other words, cathodic protection will not repair a pipe. In many cases, when a pipe is in a badly corroded condition, there are perforations in the pipe which are plugged from leaking by the rust coating and the compacted soil backfill. If cathodic protection is applied to a pipe that is rusted, the film of hydrogen gas that forms on the pipe as a result of cathodic protection will loosen this rust from the surface of the pipe. If this same rust coating is acting as a plug for the perforations in the pipe, then the application of cathodic protection will result in the loosening of these rust "plugs" and leaks will be observed.

The inspection of the piping indicated that rust is acting as a "plug" for leaks in some of the piping at the Fair Grounds. As a result, it is not recommended that the pipe system at this facility be placed under complete cathodic protection because of the poor condition of the pipe. This was illustrated by the fact that at one location where the pipe was exposed for inspection it began to leak when the rust was removed from its surface.

Due to the cost of repairs, it is anticipated that in the near future most if not all of the older piping will be replaced. However, whether or not the pipe that has been installed within the last ten years will be replaced will depend upon economics and its leak frequency. Two leaks have been repaired in this relatively new pipe that has been in service for about eight years.

In order to extend some measure of control of the leaks that will continue to occur on this new pipe, it is recommended that "hot spot" cathodic protection be applied by the maintenance crew. This "hot spot" protection consists of installing a magnesium anode at the location of a repair. The placement of the anode will aid in preventing any additional corrosion in the area of repair. It is believed that this is the most economical approach to this corrosion problem. The cost of engineering and a contract for the installation of a more elaborate system of corrosion control would probably exceed the cost of replacing the pipe under consideration.

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VI. TENTATIVE SPECIFICATIONS

Sacrificial Anodes - Galvanic

Dow Type 32-D galvo-pak (Galvo-Mag) magnesium anodes or equal with 10 foot length of lead wire.

Placement of Galvanic Anodes

1. Place anodes at least 5' from the pipe. Auger 8" diameter hole 5' 6" deep.

2. Place anode in hole and compact soil around and to the top of the anode so that the anode is firmly contacting soil on all sides.

3. Moisten anode with water until air bubbles cease to rise to the surface of the water.

4. Anode wire, which is to be buried 1' below the ground or at a depth that will protect the wire from accidental severance, should be connected to the pipe by brazing, Cadweld process, or by an approved type of compressions clamp. The electrical connections to the pipe shall be coated with "Oakite" or an epoxy type of resin coating. The protective coating over the joint of wire to pipe shall be at least 1/8" thick.

Note: The electrical connection of the magnesium anode lead wire to the pipe will automatically result in a flow of electrical current and no further work is necessary. If an additional leak occurs at a later date in the vicinity of a previously placed magnesium anode, the placement of additional anodes will be required for corrosion control. The magnesium anode will be inside a cloth sack and surrounded by a special backfill material. (Do not open or cut the cloth sack; embed the entire unit in the anode hole.)

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VII. ESTIMATED MATERIAL COST

No.	Item	Price	Total Cost
12 each	Type 32-D Galvo-Pak (Galvo Mag)	$27.04	$ 324.48

Installation of magnesium anodes at 5 man hours each.

Note: These items are not considered to be used on a contract. The installation of the anodes are only considered to be accomplished by the maintenance forces at the time a pipe is repaired. Therefore, wage scales and estimate of labor cost will depend upon the actual wage scales of personnel employed at the Fair Grounds. This information was not available at the time this report is written; therefore, complete costs were not tabulated.

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